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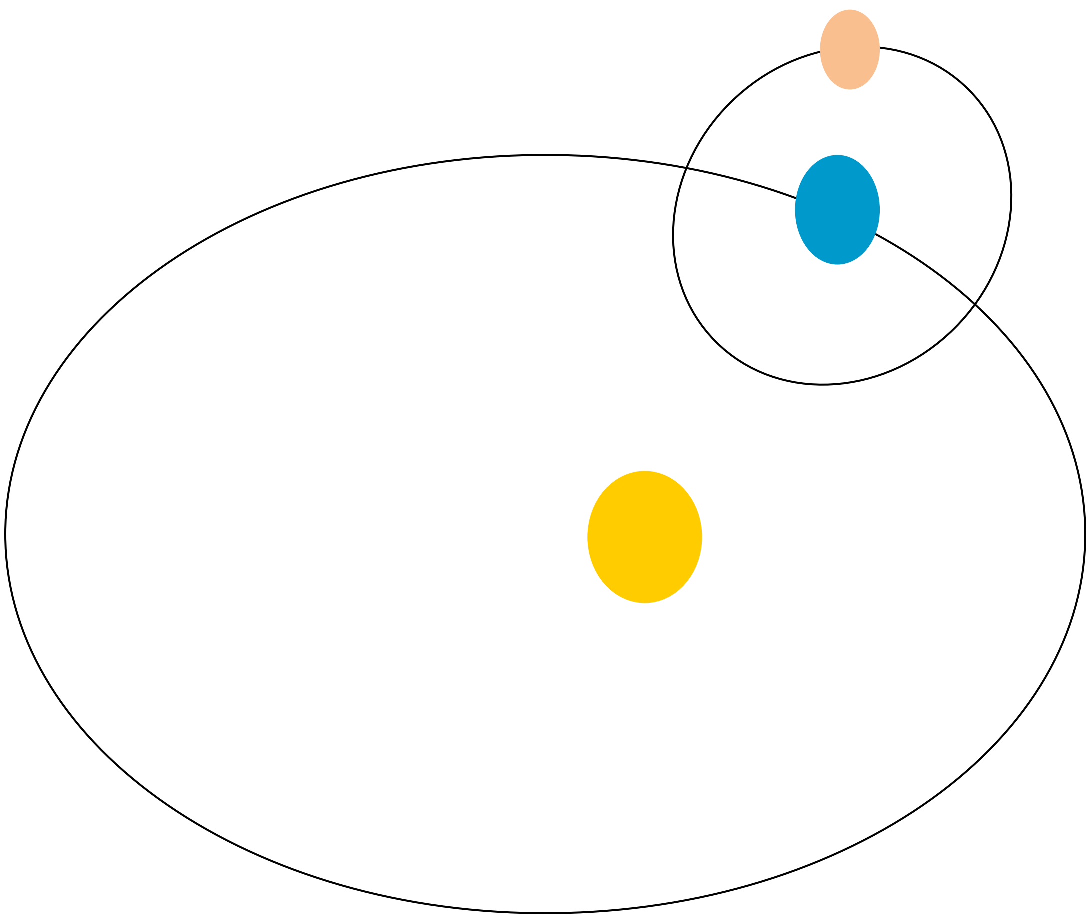

The Unanswered but Answerable Question about the Science of Climate Change

Messele Zewdie Ejeta (December 31, 2010)

Waking up recently by my alarm radio to the tune of the National Public Radio's (NPR's) Morning Edition, I heard news that Europe was getting its coldest winter since 1993. The year swiftly caught my attention because I made a quick determination as I was waking up that the winter season of 2011 is about 18 years, or one Saros cycle, from that of 1993.

According to information from the National Aeronautics and Space Administration (NASA) that is posted on its eclipse website, the Saros cycle is a period of 6585.3 days (18 years, 11 days, and 8 hours) that governs the periodicity and recurrence of solar eclipses. The information further suggests that two eclipses that are separated by a period of one Saros share a very similar geometry; the two eclipses occur at the same node with the moon nearly the same distance from the earth and at the same time of year. In this context, a node is defined as a point where the lunar orbit intersects the plane of the earth's orbit.

NASA uses Saros to organize eclipses into families or series that are identified by specific patterned numbers such as 121, 126, ..., 141, 146, or 127, 132, ..., 147, 152, and so on.

My interest in these series emerged partly as a result of involvement in the study of the impact of projected climate change on state and federal water projects in California. A preliminary report of this study was completed in 2006. The uncertainty in developing hydrological data that incorporates projected climate change to study the impact has been unsettling.

Fortunately, California has a rich record of observed precipitation data that was helpful to establish a baseline for historical level hydrology, which has been characterized as statistically stationary. In concrete terms, this means that for a climate period, which is generally 30 years according to a report by the World Meteorological Organization (WMO), the average and variation of observed precipitation data remain nearly constant.

This constancy has been ascertained through the analyses of over a century of observed precipitation data at multiple gauging stations and estimated natural streamflows of multiple watersheds in California.

The observation from these analyses led to the formulation of what I call the Paradoxical Hydrological Stationarity Problem. For example, using the precipitation data at Davis, California, where well over a century of continuous records exist, the average data for any given climate period closely approximates the corresponding data for any other climate period that has recorded data.

The paradox lies in the fact that this is a unique problem in which the moving average of a continuous subset of any n data points (30 years in this case) from a total set of N data points (over 100 years) is predictable with a very high degree of certainty whereas the variability of the individual components could not be predetermined, at least so far. The intersection of the observation of the paradoxical problem and Saros series as well as cycles led to uncovering two phenomena that may be of paramount importance to understanding climate science better. Besides furthering our understanding of climate science, the solution of this paradoxical problem can be useful for various important applications.

The first phenomenon is that based on local precipitation data in California, when the moon is nearly the same distance from the earth at the same time of year, similar hydrological conditions are observed on earth. It is therefore likely that the similarity of the snowfall in Europe, as well as hydrological and climate conditions elsewhere, in the winters of 1993 and 2011 points to this phenomenon. It should be noted here that so far while the Saros series are used as a guide for such comparisons, the basic determinant appears to point to the spatial and temporal position of the moon relative to the earth and sun.

Even though it may sound insurmountable for the layperson to know the distance of the moon from the earth at the same time of year, there are readily available proxies to achieve this objective. Solar and lunar eclipse events and the Saros series established for both the historical period and into the future can be used to get a glimpse of the whereabouts of the moon in the earth-moon-sun space during any given season.

For instance, the similarities in the positions of the moon in 1993 and 2011 in this space can be easily gleaned from these proxies. The closest Total solar eclipse to winter 1993 occurred on June 30, 1992, and belongs to a Saros series of 146 and had eclipse magnitude of 1.059. Similarly, the closest Total solar eclipse to winter 2011 occurred on July 11, 2010, which also belongs to a Saros series of 146 and had eclipse magnitude of 1.058. While both have the same Saros series of 146, nearly the same eclipse magnitudes, and are one Saros cycle apart, they occurred nearly 11 days apart in their respective years, which can be practically considered approximately the same time of year.

While the closest solar eclipse and its Saros series for a specified period, such as winters of 1993 and 2011, provide some basic information to get a good glimpse of the moon's rotational position, looking at the priori and posterior eclipses and their characteristics may reinforce the reference for a given season or year. To this effect, there was an Annular solar eclipse of Saros series 141 and eclipse magnitude 0.918 on January 4, 1992, and another Annular solar eclipse of Saros series 128 and eclipse magnitude 0.943 on May 10, 1994. Similarly, there was an Annular solar eclipse of Saros series 141 and eclipse magnitude 0.919 on January 15, 2010, and another Annular solar eclipse of Saros series 128 and eclipse magnitude 0.9439 expected to occur on May 20, 2012. Thus, the eclipse events and their characteristics around the two winters are very similar and suggest that the moon would be about the same distance from the earth at the same time of the year during these seasons.

The analyses of regional precipitation data in California using this approach has led to, in hindsight, the prognosticative ability for regional wet and dry years (multiple manuscripts have been prepared about these analyses by this author and submitted to scientific journals for peer review and possible publication).

The second phenomenon, which seems unrelated to the first, but apparently associated with it is earthquake predictability. This phenomenon was uncovered after analyzing the gap between solar eclipse and earthquake events (greater than or equal to 7 on the Richter magnitude scale) by using over a century of datasets recorded by NASA and the United States Geological Survey (USGS), respectively. One of the best examples to explain this gap may be the catastrophic earthquake in Haiti on January 12, 2010, and solar eclipse event on January 15, 2010, a gap of about three days. Another example is the December 26, 2004, Indian Ocean earthquake and tsunami, which occurred on a full moon day and about two lunar cycles after the October 28, 2004, lunar eclipse. Over the past one hundred years, the average gap is about 12 days. This figure can be further refined by considering proximate alignments such as the full moon day major earthquake and tsunami approximately two lunar cycles after a solar eclipse event.

Although these initial findings are undergoing further investigations, it appears that the driver for the earthquake is tidal dynamics according to Newton's law of universal gravitation. It has been established that this dynamics is enhanced when the moon and sun are aligned as observed from the earth.

To the extent that there is a strong association between temperature and precipitation, it is also very likely that similar temperature regimes could be felt on earth during two years when the moon's relative position is at the same distance from earth at the same time of year.

However, whether it is the 1) inertia of differential movements of the moon around the earth and the moon and earth around the sun or 2) gradient in the radiation the earth receives according to the relative positions of the earth and moon with respect to the sun which predominantly determines earth's climate and hydrology remains to be seen.

Nonetheless, both phenomena appear to point to the possibility of establishing a baseline for deterministic hydrology and climate. This baseline can be used to measure the marginal effect of elevated green house gases (GHGs) in earth's atmosphere on its climate and may well be what could bring together the different views on projected climate change. These views range from looking at the science of climate change as utilitarian for non-scientific ends to proven science to humanity's naivety in misunderstanding the effect on climate of the level of GHGs in earth's atmosphere. The unanswered question is in regard to establishing a reference that is based on evidently deterministic physical processes instead of using the realizations caused by these processes as statistical data.

To the extent that these findings can be ascertained through further analysis on a global scale, they are probably some of the crucial advances made by pushing on the frontier of the science of climate and climate change. If we have made an important step in the realization of the movement of the earth around the sun, the realization that physical processes on earth, including hydrological variability, are associated with the cyclic movements of the earth and moon in a deterministic way marks another milestone on top of that important step. This understanding may bring the prediction of various phenomena on earth one important step closer to our predictive capability of the winter and summer seasons of a year. Afterall, future may well be a construction of our perception of the reality of a moment in the space, which may be cyclically deterministic.

The Paradox of Stationarity in Hydrology: Toward a Deterministic Solution[1]

Messele Zewdie Ejeta

Abstract

A retrospective analysis of over a century of observed full natural flow data of four rivers in California shows that the average water production of each river could have been predicted with about 96% precision on a climate time scale. Paradoxically, the water production of the watersheds for shorter periods could not have been predicted with the same level of precision. The realization of this level of stationarity and its counter intuitive paradox for a shorter period avail us a unique problem in which the moving average of a continuous subset of any *n* data points from a total set of *N* data points is predictable with a very high degree of precision whereas the natural variability of the components in each subset remains to be meaningfully characterized. This paper: 1) provides a formulation for this uniquely paradoxical problem of stationarity, and 2) presents empirical evidences for possible forcing factors of stationarity, as observed in tide level trend shifts in the Pacific Ocean, long-term natural streamflow extremes in California, and the shift in the phases of the Pacific Decadal Oscillation (PDO). The implication of this formulation and the presentation of these empirical evidences appear to point to underlying forcing factors that can be generally characterized beyond what has been understood so far. The characterization and solution of the problem will have immense importance for a robust water resources planning as well as for the prediction of extreme events such as droughts and floods, including under projected climate change scenarios.

Introduction

Stationarity has been qualitatively described as the idea that natural systems fluctuate within an unchanging envelope of variability (Milly, et al. 2008). While the hydrologic cycle theory attempts to explain the path for the transfer of water from one state to another and its distribution within a given state, it lacks a robust metric that is based on a deterministic process to measure the transfer rate of water from one store to another. The efforts of hydrologists to close earth's water balance by measuring where and in what quantities earth stores water and how water moves between those stores are yet to provide convincing results (Lettenmaier and Famiglietti, 2006). To the extent that quantifiable water amounts in earth's stores can be linked to earth's climate

[1] This article was submitted on January 9, 2010, to the Journal of Hydrology for review and possible publication. A letter of rejection was received on August 28, 2010, nearly 9 months later.

or vice versa, a better understanding of the natural mechanisms that cause the transfers of water from one store to other stores is essential for the analysis of both the natural and possibly induced variability in hydrological data. A closer study of the forcing factors for these transfers and their periodicities is likely to hold the keys to solve the unique problem of stationarity that is formulated herein and supported by over a century of observed full natural flow data of four major rivers in the San Joaquin Valley of California. Thus, the first effort of this paper is to present this formulation as a quantitative representation for the idea of stationarity as an added value to its qualitative description that was noted earlier. The second effort of this paper is to present observed empirical evidences relating the shifts in the trends of tide levels in the Pacific Ocean, long-range natural streamflow extremes in California, and the shift from cool to warm phases in the Pacific Decadal Oscillation (PDO).

A full natural flow, which is also called unimpaired runoff, is defined by the California Department of Water Resources as the flow that represents the natural water production of a river basin, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds (CA DWR, 2009). For a given river location, this flow is estimated by adjusting the recorded or gage flow for upstream operations for the built environment. The four river locations in California's San Joaquin Valley where over a century of estimated full natural flow data is used for this study include: 1) Stanislaus River at New Melones Dam, 2) Tuolumne River at New Don Pedro Dam, 3) Merced River at Lake McClure, and 4) San Joaquin River at Friant Dam, which are all in the western foothills of the Sierra-Nevada mountain range.

The nature of this unique problem of stationarity, as realized by the observed full natural flow data of these rivers according to the stationarity formula presented in this paper, is likely to be a function of measureable forcing factors and their periodicities that can be characterized. If done successfully, this characterization will enable us to predict over an extended period of time the transfer rate of water from one store to another, which will have immense significance for a robust water resources planning as well as the management of extreme events, such as droughts and floods.

Several researchers have been making efforts to characterize discernible forcing factors such as solar forcing (Willett, 1974) and multi-decadal variations due to natural factors such as the North American Oscillation (McCabe, et al., 2004, McCabe, et al., 2007). However, long-term prediction of quantifiable river flow that is not predicated on the statistics of observed data is currently practically non-existent. Willett (1974) made an important effort to link solar-climatic cycles to climatic trend forecasting.

McCabe, et al. (2004) and McCabe, et al. (2007) attempted to link drought occurrences in the conterminous United States and sea surface temperature variability in both the tropical Pacific and North Atlantic oceans on a decadal to multi-decadal time scales. Wu, et al. (2009) presented an empirical model to predict the East Asian Summer Monsoon strength using the El Niño Southern Oscillation (ENSO) and the spring North Atlantic Oscillation (NAO).

These empirical evidences appear to show correlations between the momentum of the trends of these natural variables and the unique problem of stationarity that was realized in the full natural flow data of the four rivers. Even though emerging studies suggest that stationarity is dead (Milly, et al., 2008), the discernible factors behind the above variables and stationarity are yet to be definitely characterized. In the likely scenario that these factors contribute to the realization of stationarity, they may continue to play a dominant role even under presumed dead stationarity, or projected climate change. In other words, even in the projected altered state of the earth that has been attributed to elevated green house gas concentration in the atmosphere, natural variability will most likely continue to live as the undercurrent beneath dead stationarity. Therefore, a meaningful characterization of natural variability of the past that maintained stationarity will help in the attribution of future variability due to nature and the influence of humans.

Stationarity in Observed Data

The long-range observed full natural flow data by water year is used herein to provide an overview of stationarity. In California, a water year runs from the beginning of October of the previous calendar year to the end of September of the current calendar year. This characterization of a water year was recommended by Loewe and Radok (1948) to avoid splitting the Southern Hemisphere summer wet season, or equivalently, the Northern Hemisphere winter wet season. Although precipitation data would be preferable for such an analysis, since it doesn't contain possible bias due to the abstraction, surface evaporation, and infiltration of water, long-range and distributed historical precipitation data is not as widely available as the flow data. Thus, the flow data is used as a proxy for the precipitation data.

The analysis of the full natural flow data of the four major rivers in California using a 30-year climate period's moving average flow traces for these rivers shows that the average water year flow for any given climate period since 1901 is nearly deterministic, as shown in Figure 1. The long-range average water productions of the Stanislaus, Tuolumne, Merced, and San Joaquin rivers that drain to the stated locations are 1.2, 1.9, 1.0, and 1.8 million acre-feet, respectively. Note that the graph shows pronounced peaks for the climate periods ending in water years 1938 and 1998 and a pronounced trough for the climate period ending in water year 1968. Note also that the trough is situated between the peaks, thus suggesting conceivable periodic characteristics in the data. This will become more apparent that looks at the time series residuals of stationarity (Figure 2). Although these pronouncements don't appear to be particularly large for a 30-year average data, they are caused by single data points that stand out from among the data points used in the averaging.

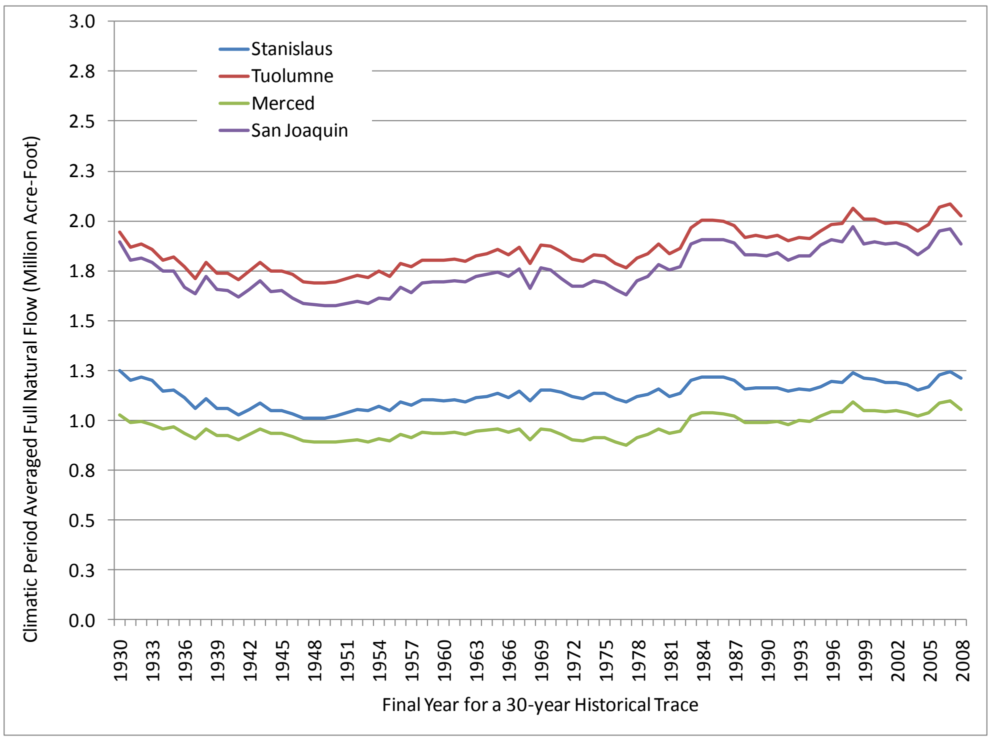

Figure 1. Observed 30-year moving average trace of full natural flow data of the four major rivers in the San Joaquin Valley of California

Formulation of the Hydrological Stationarity Problem

As the 30-year moving average traces in Figure 1 show, the trend lines of the graphs for all the four rivers have nominal slopes and practically identical patterns over time throughout the period of record. For any given period of consecutive 30 years, the average water production of any of the watersheds can be well estimated by the long-term average water production of the respective watershed. Thus, if $Q_1, Q_2, Q_3, \ldots, Q_N$ are the water year full natural flows of a given river for N years where $N \geq 30$, we can define the average water production of the watershed using a simple arithmetic mean formulation given by Equation 1.

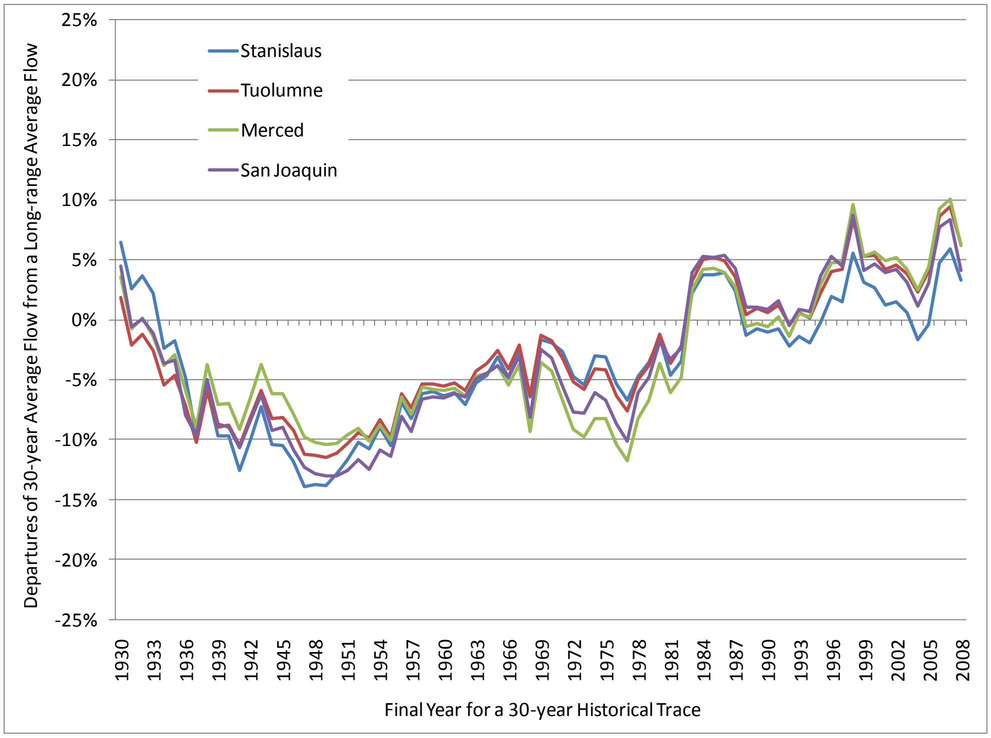

Figure 2. Departures from 30-year moving average trace of full natural flow data of the four major rivers in the San Joaquin Valley of California

$$Q_y = \frac{\sum_{i=1}^{N} Q_i}{N} \qquad (1)$$

where Q_y is the average water production of the watershed.

For any n consecutive water years that are a subset of N water years, the paradoxical stationarity problem, using observed full natural flow data as a case example, is formulated as follows.

$$Q_y = \frac{\sum_{i=1}^{n} Q_i}{n} - \varepsilon_1 = \frac{\sum_{i=2}^{n+1} Q_i}{n} - \varepsilon_2 = \frac{\sum_{i=3}^{n+2} Q_i}{n} - \varepsilon_3 = \cdots = \frac{\sum_{i=(N-n+1)}^{N} Q_i}{n} - \varepsilon_{(N-n+1)} \qquad (2)$$

where $\varepsilon_1, \varepsilon_2, \varepsilon_3, \ldots \varepsilon_{(N-n+1)}$ are residual departures from stationarity. For practically insignificant residuals, Equation (2) may be rewritten as follows:

$$Q_y \approx \frac{\sum_{i=1}^{n} Q_i}{n} \approx \frac{\sum_{i=2}^{n+1} Q_i}{n} \approx \frac{\sum_{i=3}^{n+2} Q_i}{n} \approx \cdots \approx \frac{\sum_{i=(N-n+1)}^{N} Q_i}{n} \qquad (3)$$

Both equations (2) and (3) can be extended to all other variables that have the characteristics of stationarity. The period *n* that is used for averaging to establish stationarity may be called the stationarity period. The residual departures, ε_1, ε_2, ε_3, …, $\varepsilon_{(N-n+1)}$, may be called the departures from stationarity. Under theoretical stationarity:

$$\lim_{p \to n} \varepsilon_1 = \lim_{p \to n} \varepsilon_2 = \lim_{p \to n} \varepsilon_3 = \cdots = \lim_{p \to n} \varepsilon_{(N-n+1)} = 0 \qquad (4)$$

where p is the test case period for the stationarity period n, which could vary from an instantaneous time, such as for the measurement of the mass of a stable atom, to infinity, such as for the known state of our universe. Under practical stationarity, equation (4) may be modified as follows:

$$\frac{\sum_{i=1}^{N-n+1} \varepsilon_i}{N-n+1} \le \varepsilon_T \qquad (5)$$

where ε_T may be called the average tolerance limit for departures from stationarity.

As the data of the graphs in Figure 2 indicate, the average of the departures from stationarity of all the successive 30-year periods from the long-term average of the full natural flows of all the four rivers is about -3%. The biggest observed departure is about -14% for the Stanislaus River above New Melones Dam during the 1925 – 1954 climate period. In hindsight, at any time in the past since 1901, the average water productions of any of these watersheds for the subsequent 30 years could have been predicted with about 96% precision on average and 86% precision in the worst case scenario. Therefore, the paradox of this problem is that if the water production of a watershed for the next thirty years, starting any year in the last century, could be predicted with this high level of precision, why can't the water production of the same watershed for the subsequent 5 or 10 years be predicted with the same level of precision? This is a counter-intuitive problem that demands characterizing the causes. Further investigation of observed empirical evidences that relate extreme data points of interest in the stationarity with the trend shifts in the Pacific Ocean tide levels and the phase shifts in the PDO may provide an area of focus in continuous endeavors to solve this unique problem.

Tide Level Trend Shifts

Figure 3 shows the Pacific Ocean's tide level for the period of 1900 to 2007 as observed at the Golden Gate Bridge, off the coast of California near San Francisco. A 19-year moving average of this tide level data is also shown in Figure 3 for three time segments, which show apparent shifts in trend. These segments are the 19-year periods ending between 1918-1933, 1934-1998, and 1999-2007. Using the slope of the trend line for the 19-year moving average that ends between 1918 and 1933 as the baseline, the trend line slopes for the subsequent two periods change by 5.4 and -2.6 times, respectively. From 1924 to 1998, there was a marked increasing trend in the tide levels; note that 1924 is the mid-point for the 19-year moving average that ends in 1933. Since 1998, there is a marked falling trend in the tide levels. Of particular importance here are the years 1924 and 1998, the first one being one of the two driest years on record in California since 1901 and the second one being one of the wettest years on record in California. Whether the marked falling trend since 1998 can be fully explained by arguments made in favor of global cooling since 1998 (Easterbrook, 2009) or that future warming will be strongly modulated by natural climate variations especially those driven by the slowly varying oceans on a time scale of decades (Hurrell, 2008) will be a subject of further investigation.

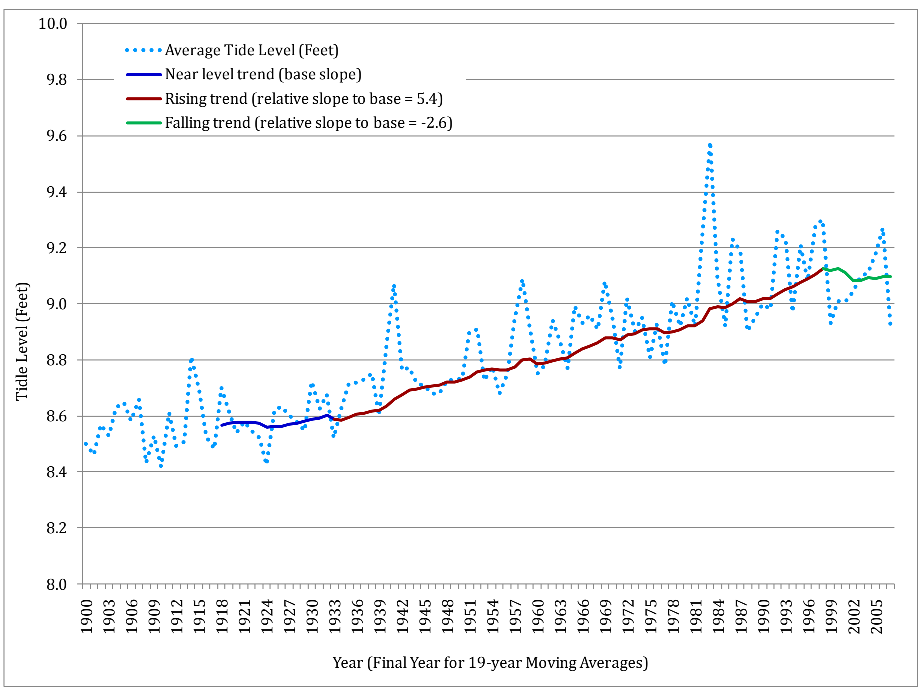

Figure 3. Pacific Ocean's tide levels and their 19-year moving averages, as observed at the Golden Gate Bridge near San Francisco

Figure 4 shows the tide level changes for the three time segments noted above. The biggest fluctuations in the tide levels were observed between 1942-1943 and 1983-1984, which were after the Dust Bowl period in the U.S. and the wettest year on record in California, respectively. Coincidentally, the time between 1983 and 1984 saw the highest tide level fluctuation on record at this location. In addition, since this highest tide level fluctuation, the positive peaks in the tide level show a dampening trend at this location.

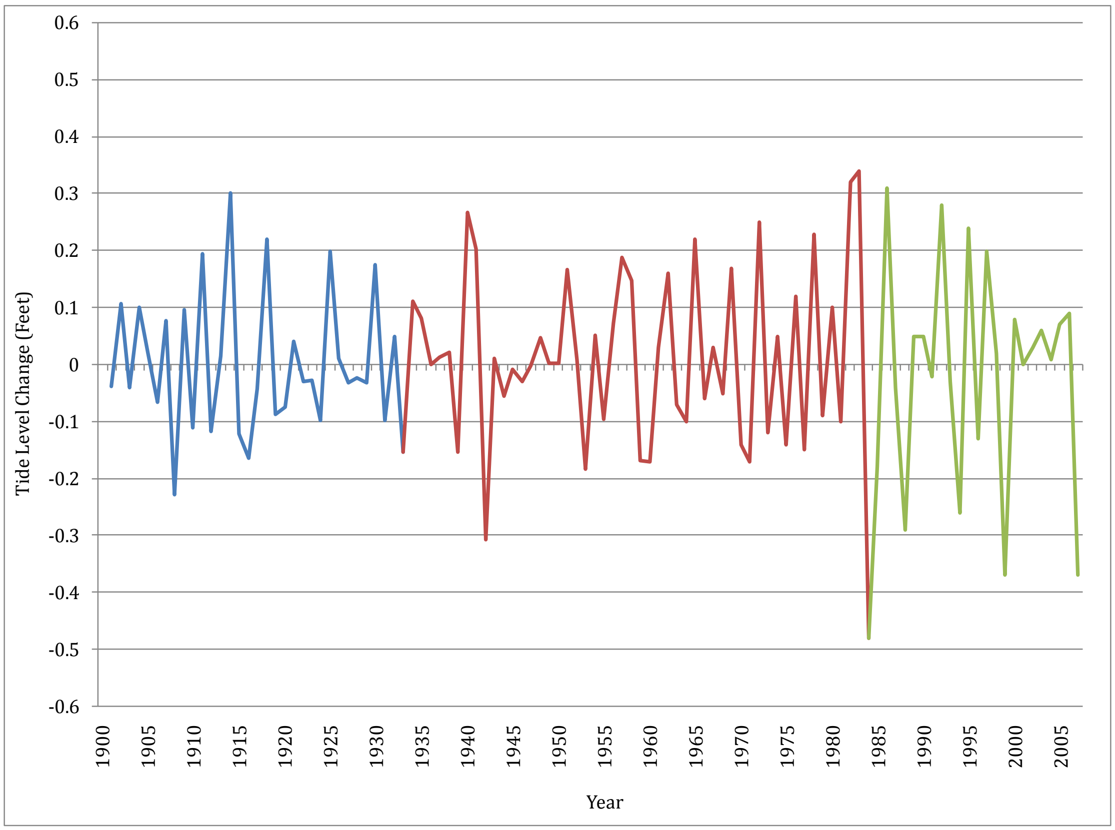

Figure 4. Pacific Ocean's tide level changes as observed at the Golden Gate Bridge

Pacific Decadal Oscillation (PDO) Phase Shifts

The Pacific Decadal Oscillation (PDO) is a long-lived El-Niño like pattern of Pacific climate variability. The PDO Index is defined as the leading principal component of North Pacific monthly sea surface temperature variability (pole ward of 20^o north for the 1900–1993 period). "Cool" PDO regimes prevailed from 1890 – 1924 and again from 1947 – 1976, while “warm” PDO regimes dominated from 1925 – 1946 and from 1977 through at least the mid 1990’s (University of Washington, 2009).

The analysis of the full natural flows of the four major rivers in California in relation to the PDO Index showed a strong correlation between the two “cool” to “warm” PDO regime shifts on record and the two lowest natural streamflows on record since 1901. For all these rivers, the two lowest natural flows occurred in 1924 and 1977 whereas the two “cool” to “warm” PDO regime shifts are noted to have occurred between 1924 and 1925 and 1976 and 1977.

Discussion

Going beyond a qualitative description of the idea of stationarity, over a century of observed full natural flow data of four major rivers in the San Joaquin Valley of California have been used to formulate and quantitatively illustrate the idea of stationarity in hydrological data. The data shows, in hindsight, that starting any year since 1901 the water production of the watersheds of these four rivers could be predicted, on average, with 96% precision on a climate time scale of 30-years. Based on this analysis, a paradoxical question has been raised that if we could have predicted, starting from any year since 1901, the average water production of a given watershed in the subsequent 30 years with such a very high level of precision, why couldn’t have we predicted the water production of the same watershed for a shorter time period, such as 5 or ten years, with the same level of precision?

It has been argued that without some inherently underlying forcing factors that can conceivably be characterized, a subject of an ongoing investigation, there wouldn’t be such a paradoxical stationarity in hydrology. The nature of the historical departures from stationarity is far from being random. In fact, at any given time, the pattern of these residuals may provide us clues about a natural inertia of the direction of the trend of river flows on multi-decadal time scales. The inertia of these departures suggests that natural variability is likely to continue to exist beneath what is believed to be dead stationarity. Establishing a baseline for historical natural stationarity will provide a reference that can be used to estimate the shift from this baseline.

Empirical evidences relating observed full natural flow data extremes to significant trend shifts in the Pacific Ocean’s tide levels and phase shifts in the PDO that have been presented appear to provide useful information about the forcing factors for stationarity. The coincidences of these shifts and the occurrences of extreme full natural flow data points of the four rivers in the San Joaquin Valley of California appear to suggest that some relationship exist between these natural variables. To the extent that natural variability lives beneath dead stationarity, a better understanding and characterization of the natural variability component of hydrology is likely to go a long way in overcoming the uncertainties in the use of such data that is based on the results of General Circulation Modeling. The tide level trend shifts on a multi-decadal time scale appears poised to lead us to revisit the universal law of gravity that assumes the earth as a monolithic mass, instead of an integral mass with its various components that may have their own centers of masses that may shift marginally. In fact, ocean level data shows the gravitational influence of the moon and the sun on the ocean level (Rahmstorf, 2002). The current assumption is that the gravitational pull of the ocean mass by the sun and the moon leaves the ocean tide's wave front in its integrity, which is a subject of focus in ongoing investigations as part of an effort to move toward a deterministic solution for the paradoxical hydrological stationarity problem.

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A New Insight towards Earthquake Prediction

Messele Zewdie Ejeta

Abstract

A new analysis of over a century of the world's recorded major earthquakes ($M \geq 7.0$ where M is the Richter magnitude scale) and solar eclipse events was conducted using the number of days between the occurrences of the two sets of events as a determinant variable for earthquake predictability. The result shows a remarkable relationship between these sets of events, as evidenced by a Gaussian distribution of the determinant variable, which has a mean of 11.6 days. In hindsight, the recorded major earthquakes during the last over 100 years could have been predicted to occur, on average, within a few days of the occurrences of solar eclipse events. A closer analysis of reported earthquakes around the January 15, 2010, solar eclipse event shows that on average, these reported earthquakes occurred within 2.65 days of the alignment or proximate alignment of the earth, moon, and sun. Solar eclipse events and the phases of the movement of the moon around the earth are used as proxies for deciphering the alignment or proximate alignment of the earth, moon, and sun. Based on this premise and the resulting analysis, it is inferred that the near coincidental occurrences of major earthquake events when the earth, moon, and sun are aligned or closely aligned in the earth-moon-sun space, and possibly other celestial objects, points to the utility of the inverse-square law in Newton's universal law of gravitation for earthquake prediction. This discovery is poised to bring the predictability of earthquakes within a close reach and signals enormous implications for policy and decision makers. Towards this end, this insight highlights the need for the creation of a vector field in the sun-moon-earth space and a further characterization of historical earthquakes and their locations in relation to the concurrent positions of these celestial objects in this vector field, a subject of an ongoing investigation.

Introduction

In January 2010, at least three notable natural phenomena have occurred: the tragic earthquake in Haiti on January 12, 2010, an annular solar eclipse on January 15, 2010, (NASA, 2010), and a severe thunderstorm patterns over the western United States with a strong upper level jet of very high velocities during the third week of the same month. After the prediction of the severe thunderstorm over the western United States, the National Weather Service issued a rare tornado warning for Northern California's Contra Costa County.

The minimization of the enormous societal and economic impacts due to naturally occurring hazardous disasters have long been challenges to policy and decision makers. Earthquake is one of the natural hazards that disrupt California's costly infrastructure systems (California Natural Resources Agency, 2009). Empirical earthquake predictions that attempt to narrow prediction time windows from several years down to months have the potential to lead to the reformulation of disaster preparedness (Davis, et al., 2010). The Seismological Grand Challenges Writing Group recently identified 10 basic challenges in seismology that need to be put at the forefront of research on earth systems (Lay, et al., 2009). Thus, the commitment for better predictions of natural disasters to minimize their impact on the society and built environment continues to attract the interests of policy and decision makers.

Many questions about the causes of earthquakes have remained not fully explained. An interpretation of the processes responsible for tremor generation is yet to be determined (Thomas, et al, 2009). Non-volcanic tremor that was discovered nearly a decade ago has led to the suggestion that seismic energy can be generated from a region of the earth that was previously thought incapable of generating it (Obara, 2002). Shelly, et al (2007) suggest that non-volcanic tremor is a weak, extended duration seismic signal observed episodically on some major faults, often in conjunction with slow slip events. They further suggest that tremor may hold the key to understanding fundamental processes at the deep roots of faults, and could signal times of accelerated slip and hence increased seismic hazard. The motions of plate tectonics give insight into both the locations and average recurrence interval of future large earthquakes on plate boundaries, yet they give no insights into where and when earthquakes will occur within plates (Stein and Liu, 2009). A further study by Shelly (2010) demonstrates a systematic recurrence of tremor, thus suggesting a potential for monitoring detailed time-varying deformation. The study hasn't yet provided a prognostic capability for earthquake prediction. One of the latest research reports by Grant and Halliday (2010) that is based on monitoring common toad population prior to and after the April 6, 2009, earthquake in Italy suggests that this population responded to an impending earthquake by fleeing their spawning habitat five days prior to the earthquake event. However, they conclude that it is unclear what environmental stimuli these animals responded to in advance of the event.

Panakkat and Adeli (2008) broadly group prediction efforts in the last nearly two decades into theoretical geophysics, heuristic genetic algorithms, and statistical and mathematical approaches that are based on historical earthquake catalogs in seismic regions. Despite the complexity of these undertakings, they recommend that the scientific community pursue earthquake prediction vigorously in view of the necessity for emergency management and hazard preparedness. Hiroshi and Masakuzi (2002) studied the effects of earth tides on earthquake occurrences using a numerical simulation approach. In their simulation, starting from different initial stresses, fault planes were stressed by constantly increasing tectonic and cyclic tide loads and observed that the simulated earthquake occurrence is strongly controlled by the change of the tide stress relative to stress accumulation. The study thus suggests possible triggering of earthquakes by earth tides but did not provide a procedure for earthquake prediction. According to Diacu (2009), the efforts of mathematical models at predicting natural disasters such as earthquake have been hardly dependable.

A recent study by this author on the traditional assumption of stationarity in hydrology suggests that a conceivable relationship exists between solar eclipse trajectories over two years and wet and dry spells in Northern California. Further analysis of over a century of earthquake and solar eclipse events shows a strong association between these two events. This further analysis reveals that from nearly 350 recorded major earthquakes that have happened since 1901, the average gap between solar eclipse events and major earthquakes is about 11.6 days; nearly half of them occurred within 45 days of recorded solar eclipses. Furthermore, the analysis of these occurrences by taking into consideration the new and full lunar cycles as proxies for the evolving and decaying solar eclipse events significantly reduces the gap. Specifically, this further analysis was done using the recorded earthquakes around the January 15, 2010, solar eclipse event and during the four lunar cycles that encompass it. The result of this further analysis shows that on average, these reported earthquakes occurred within 2.65 days of the alignment or close alignment of the earth, moon, and sun (Figure 1). In general, there is a strong observed relationship between reported earthquakes and shorter distances between the earth, moon, and sun as formulated by Newton's universal law of gravitation and evidenced by the association between historical solar eclipse occurrences and major earthquakes. It is evident that when these celestial objects are aligned, the resultant distance between these objects is smaller, which implies greater resultant gravitational forces on these objects, according to Equation 1:

$$F = G.m_1.m_2/r^2 \qquad (1)$$

where F is the magnitude of the gravitational force between two point masses, G is the gravitational constant, m_1 is the mass of the first point mass, m_2 is the mass of the second point mass, and r is the distance between the two point masses.

Data Sources and Analysis

Historical solar eclipse data for 1901 to January 2010 were obtained from the National Aeronautics and Space Administration's (NASA) Eclipse website (NASA, 2010). Recorded worldwide historical earthquakes are available from the United States Geological Survey's (USGS) Historic World Earthquakes website (USGS, 2010). According to this USGS data set, there have been nearly 350 recorded and documented major earthquakes ($M \geq 7.0$) since 1901.

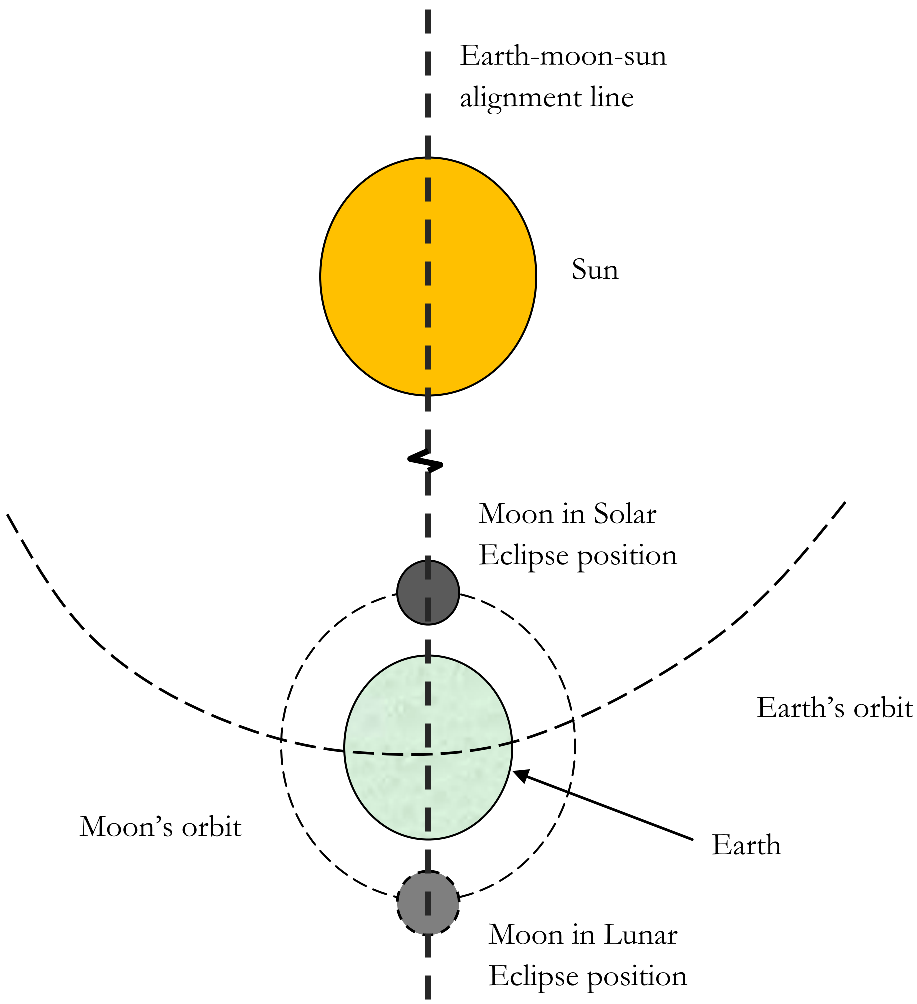

Figure 1. Schematic depiction of the earth-moon-sun alignment (not to scale)

Using these two data sets, this study analyzed the association of recorded solar eclipse events with major earthquakes during the 1901 to January 2010 period. The number of days between solar eclipse and major earthquake events was computed for each recorded earthquake during this period. A statistical characterization of this derived data has shown a remarkable relationship between the two sets of events. Figure 2 illustrates the number of days between solar eclipse events and between solar eclipse and major earthquake events.

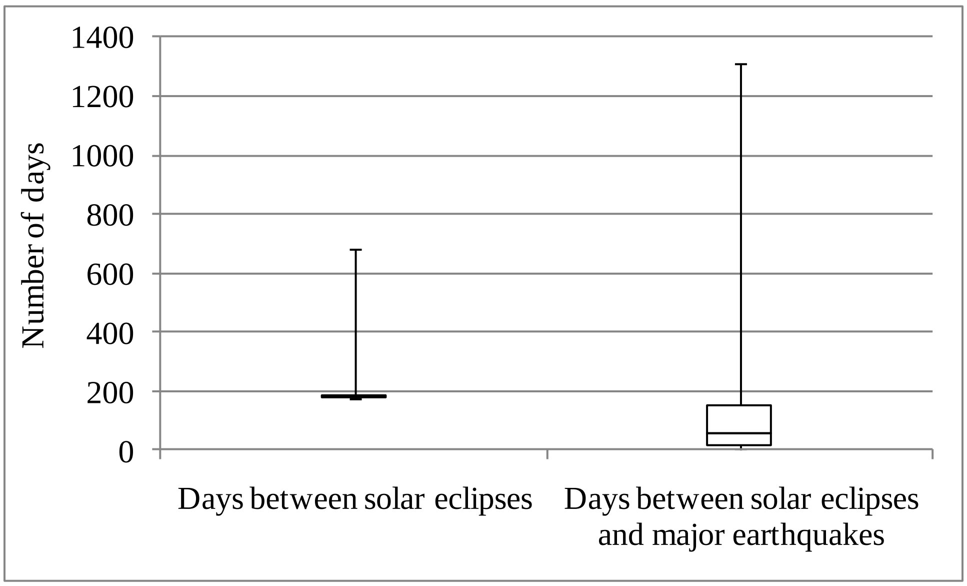

Figure 2. Box plots showing the frequencies of solar eclipse events and the gap between solar eclipse and major earthquake events for the 1901 to 2010 period

While the number of days between solar eclipse events is predictable (about 177 days in general), the average gap between the occurrence of solar eclipse and major earthquakes is very narrow as shown in the second box plot in Figure 2. This gap, which has a mean of 11.6 days and standard deviation of 104 days, is normally distributed as shown in Figure 3 and Figure 4. The outlying number of days between solar eclipse and major earthquake events in the second box plot in Figure 2 shows an absence of a recorded major earthquake between 1981 and 1985. The USGS has no data for a major earthquake during this period, which incidentally is the wettest spell over the western United States in over a century. It is arguable that large number of days between major earthquakes may not necessarily mean the absence of this class of earthquakes. This is because not all the terrestrial and oceanic parts of the earth are equipped to record earthquakes. In addition, the absence of a solar eclipse in a given period may not necessarily mean a lack of a close alignment of the moon and sun relative to the earth during that period. Thus, it is arguable that some of the bigger gaps may likely be minimized if such close alignments are taken into account.

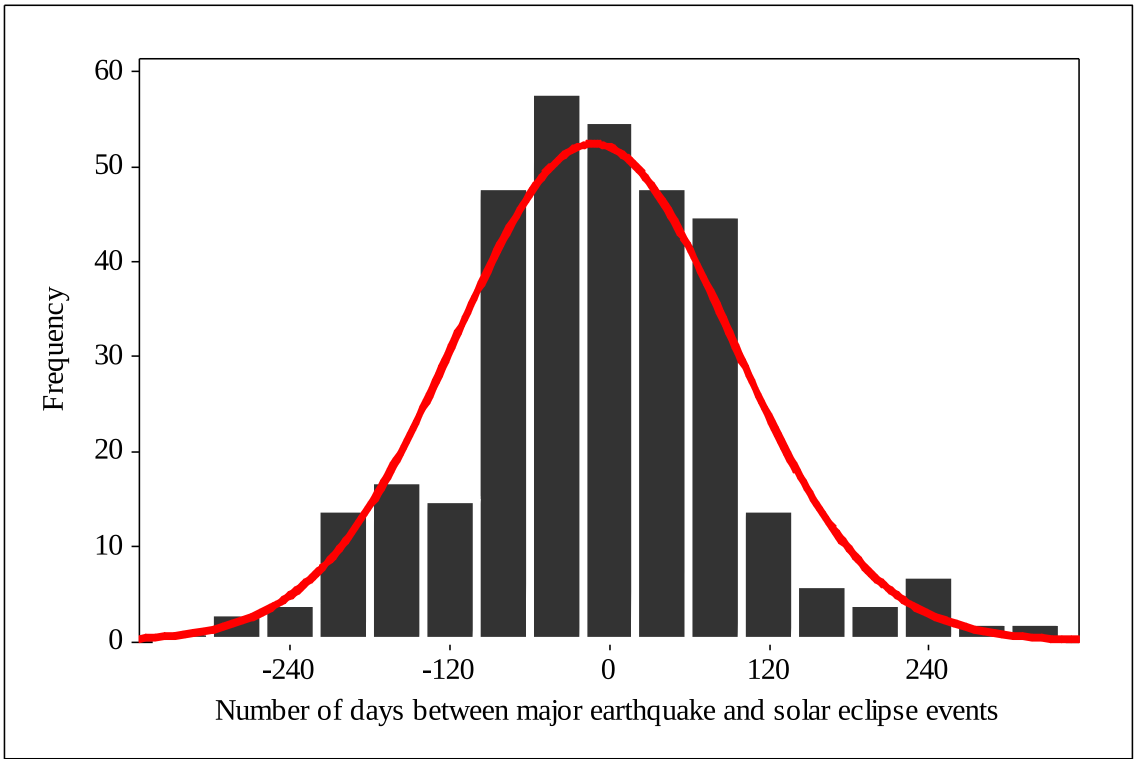

Fig. 3. Frequency distribution and normal distribution fit of the number of days between major earthquake and solar eclipse events for the 1901 to 2010 period

The Gaussian distribution in Figure 3 is, therefore, a preliminary characterization of the occurrence of major worldwide earthquakes relative to those of solar eclipse events during a period of over a century. Thus, this distribution points to a useful tool for earthquake predictability. As a selected sample illustration, the numbers of days between solar eclipse events and selected major earthquakes during the 2001 to 2010 period are presented in Table 1. According to this data set, on average, these selected earthquakes during the last decade occurred within about 2.6 days from the recorded solar eclipse events.

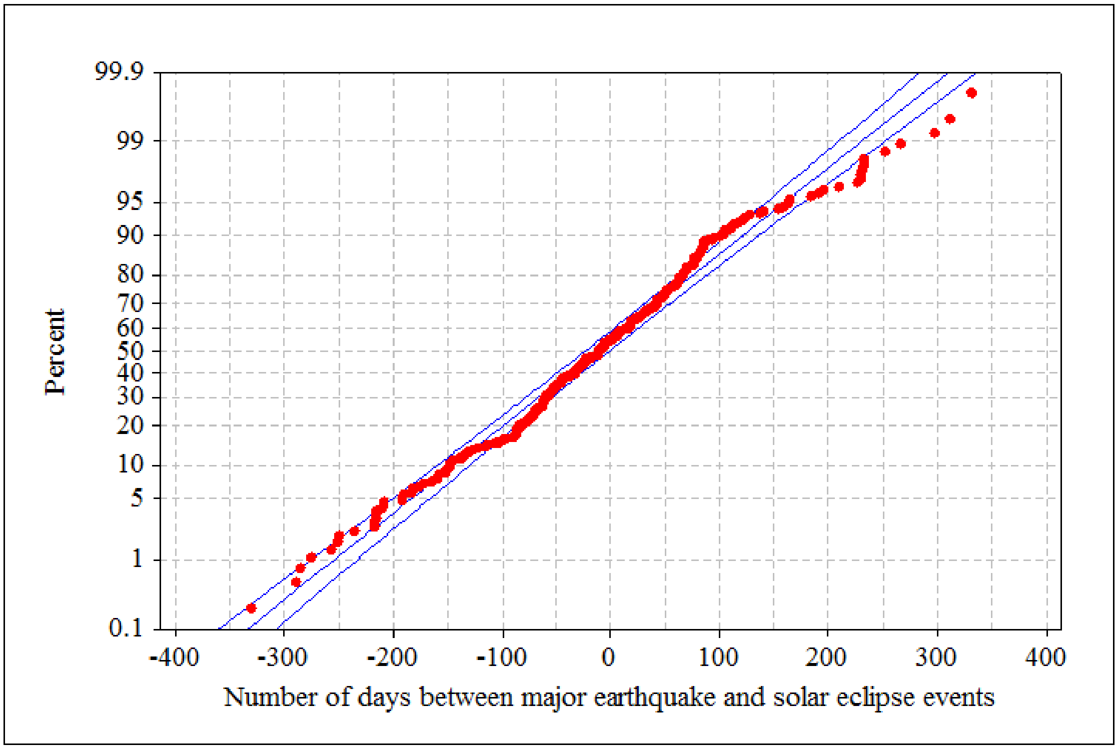

Fig. 4. Probability plot showing the number of days between major earthquakes and solar eclipse events for the 1901 to 2010 period

By focusing on all recorded earthquake events during about four lunar cycles around the January 15, 2010, solar eclipse (November 15, 2009, to March 15, 2010), it was found that, on average, these reported earthquakes occurred within 2.65 days of the alignment or proximate alignment of the earth, moon, and sun. For the purpose of this analysis, a proximate alignment of the earth, moon, and sun is assumed to have occurred about 15, 30, 44, and 59 days before and after the solar eclipse event. This assumption is based on the 29.5 days of full lunar cycle and the nearly 15 days between new moon and full moon phases. It should be noted that these three celestial objects get nearly aligned twice during a full lunar cycle. Table 2 shows the results of this focused analysis.

Table 1. Gaps (in day) between solar eclipse and selected major earthquake dates during the 2001 to 2010 period

Solar eclipse date	Earthquake date, location, and magnitude			Gap (days)
	Date	Location	Magnitude	
1/15/2010	01/12/2010	Haiti	7.0	-3
7/22/2009	07/15/2009	Near South Island, New Zeland	7.8	-7
1/26/2009	01/15/2009	Kuril Islands, Russia	7.4	-11
8/01/2008	07/19/2008	Honshu, Japan	7.0	-13
2/07/2008	02/20/2008	Simeulue, Indonesia	7.4	13
9/22/2006	08/20/2006	Scotia Sea	7.0	-33
3/29/2006	04/20/2006	Koryakia, Russia	7.6	22
10/03/2005	10/08/2005	Pakistan	7.6	5
10/03/2005	09/26/2005	Northern Peru	7.5	-7
4/08/2005	03/28/2005	Northern Sumatra, Indonesia	8.6	-11
11/23/2003	11/17/2003	Rat Islands, Aleutian Islands, Alaska	7.8	-6
5/31/2003	05/26/2003	Halmahera, Indonesia	7.0	-5
6/10/2002	06/28/2002	Northern China	7.3	18
6/21/2001	06/23/2001	Near the Coast of Peru	8.4	2
Average gap (days)				-2.6

Discussion

Various past studies on earthquake phenomenon have envisaged prognostic capabilities for its occurrences so that the damage this natural hazard causes may be minimized. This new study has attempted to show that the alignment of the moon and the sun relative to the earth has left yet another footprint in earthquake occurrences. In light of the finding of this novel association, it is also possible that the suggested predictive capability of male toad population behavior (Grant and Halliday, 2010) to impending earthquake may be linked to the gradual approach of the alignment or close alignment of the earth, moon, and sun that the amphibian population is sensitive enough to in one way or another. The new observation of the strong relationship between the alignment of these celestial objects, as recorded through solar eclipse events and major earthquake events of over a century has enormous implications for policy and decision makers. Projected solar eclipse dates through the end of the 21st century are available from NASA and can be used to predict future earthquakes around the globe. In essence, this novel uncovering of the association between the two events will go a long way in setting in motion a more detailed characterization and accurate prediction of earthquakes. The analysis

Table 2. Number of days from the January 15, 2010, solar eclipse and proximate earth, moon, and sun alignment dates

Date of earthquake	Location and magnitude of earthquake (in brackets)	Number of days from the 1/15/2010 solar eclipse date	Number of days of proximate alignment date to the 1/15/2010 solar eclipse date	Gap (days)
3/15/2010	Biobío, Chile (6.7)	59	59.00	0.00
3/14/2010	Indonesia (6.5)	58	59.00	1.00
3/14/2010	Honshu, Japan (6.3)	58	59.00	1.00
3/8/2010	Eastern Turkey (6.1)	52	59.00	7.00
2/27/2010	Offshore Maule, Chile (8.8)	43	44.25	1.25
1/12/2010	Haiti region (7.0)	-3	0.00	3.00
1/10/2010	Offshore Northern California (6.5)	-5	0.00	5.00
1/3/2010	Solomon Islands (7.1)	-12	-14.75	2.75
12/30/2009	Baja California, Mexico (5.9)	-16	-14.75	1.25
12/19/2009	Taiwan (6.4)	-27	-29.50	2.50
11/24/2009	Tonga (6.8)	-52	-59.00	7.00
11/17/2009	Queen Charlotte Islands region (6.6)	-59	-59.00	0.00
Average gap (days)				2.65

presented herein appears poised to bring us to the verge of bringing within reach the predictability of disasters from this natural phenomenon and hence minimizing its damage. The transfer of gravitational force between these three celestial objects to the earth's plate tectonics may well be through tidal dynamics, which is already known to be affected by the phases of the moon and the alignment of the earth, moon, and sun. Towards that end, this new insight points to the need for the creation of a vector field in the earth-moon-sun space and a further characterization of earthquakes and their locations on earth relative to the positions of these celestial objects in this vector field, a subject of an ongoing investigation.

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Ambient Temperature Environment as a Possible Causative Factor for Human Origin and Its Implications for Life's Adaptability to Projected Climate Conditions

Messele Zewdie Ejeta

Abstract

The establishment of baseline environmental conditions for plants and animals may be necessary in studying more meaningfully their migratory reactions to projected climate conditions that could be different from accustomed conditions. A better understanding of the environmental conditions that affected or controlled the evolutionary behavior and existence of life on earth is likely to ease the daunting uncertainty in determining the incremental effects of projected climate conditions on it. By analyzing the favorability of historical average temperature regimes for functional homeostasis in humans, the current work attempts to present natural ambient temperature environment as a possible causative factor for life's origin. This analysis is based on a thesis that the natural environmental conditions that favorably work today for humans had historically similar characteristics. On the basis of this thesis, it formulates and characterizes functional homeostasis regime in humans using present day's data. It applies the characterization to 36 city locations around the world to spot identify those locations that would have been naturally more favorable for the evolutionary processes in humans. The result shows that Addis Ababa, Ethiopia, has the most favorable environmental setting from these locations that would have helped functional homeostasis processes in humans. This finding is consistent with those from other kinds of analyses including deoxyribonucleic acid (DNA) and linguistics. As we try to draw a picture of past-future continuum of life on earth, this finding may serve as helpful evidence for and lead to the emerging quest to better understand the evolutionary forces that shaped and maintained it.

Introduction

Past studies on early human migration, including DNA analysis (Zhong, et al., 2010; Li, et al., 2008; Jakobsson, et al., 2008; Liu, et al., 2006), attempt to point to the geographical source of this migration. Africa, in general, and East Africa, in particular, have been noted to be the earliest habitats for the world's human population. A possible set of causative factors that made the continent and region more favorable homes for early hominids remains to be conclusively identified. Such identification is likely to have profound implications for the world's existing bio-diversity and its adaptability to projected environmental conditions.

It is presumed herein that the environmental condition that worked better in the past for bio-diversity is likely to work better in the future. Thus, this paper first theorizes that a closer look at three proxy factors would serve us as an indicator for a causative factor for a favorable home and condition for evolutionary physiological processes of early hominids. Then it demonstrates a strong correlation between the implications of this theory and the results from other forms of studies including DNA and linguistic analyses. The three factors are today's 1) long-term average temperature data of a given location as a proxy for that location's age old climate, 2) human body temperature as a proxy for an optimal condition for humanity's age old functional physiological processes, and 3) normal room or ambient temperature as a proxy for an optimal environmental condition for humanity's evolutionary physiological processes in harsh natural environment. This work specifically uses the average ambient temperature uniformity index, which is defined as a measure of the proximity of a given location's observed long term average temperature to the ambient temperature state. The proximity is measured in terms of both year round average temperature data and the inter-monthly persistence of the ambient temperate state. This uniformity index is then used to spot-identify and rank regions around the world for their favorable condition to have been the likely home of early hominids on earth before the age of the built environment. This analysis was done for multiple locations in each of Africa, Asia, Europe, North America, Oceania, and South America. The result shows that from the selected locations, Addis Ababa, Ethiopia, has the most favorable environmental setting that would have helped these processes in humans.

Methodology

The average normal body temperature of present day humans is 36.8 ± 0.7 degree Celsius (°C) (Pribor, 1986). We do not know for sure if the same or different normal body temperature prevailed in early hominids or during their evolutionary developmental processes that led to our present day's state of the normal human body system. However, for present day's state of the human body system, the normal room or ambient temperature is taken as 21 °C, according to West Midlands Public Health Observatory in England (Roberts, 2006). For the purpose of the current work, the environmental temperature range between those that cause hypothermia and hyperthermia in a human body are considered as the functional temperature homeostasis regime. This regime lies approximately between 0 °C (Hopkin, 2005) and 42 °C (Shier, 2009), the low and high point environmental temperatures, respectively, below and above which functional homeostasis gets impaired under a prolonged exposure time.

Hence, the application of the analysis in this work is based on two theories. The first theory is that the ambient temperature is a sound proxy for an optimal environmental condition in which the human body system evolved over the ages. The second theory is that a geographic region with the least overall and year round deviations of temperatures from this optimal environmental condition would have availed a more favorable natural environment for early humans and their evolutionary trajectory. On the basis of these theories, the temperature data of 36 sample cities around the world was analyzed to identify and rank those geographic locations that would have availed better environmental conditions in which the human body system could evolve with better ease.

With a temperature of 21 °C taken as the normal room or ambient temperature, the temperature departure index from the ambient state is given by Equation (1). As a measure for the ambience of environmental temperature within the functional temperature homeostasis regime, the ambient temperature uniformity index is defined as the root mean square error (RMSE) of the deviations of monthly average high and low temperatures from the ambient temperature state, which is given by Equation (2). The range index, which is a measure of the year round fluctuation between the average maximum and minimum temperature values, is given by Equation (3). Similarly, the steadiness index, which measures the year round persistence of the average maximum and minimum temperatures of a given location, is defined by Equation (4). This index indicates the absolute shifts of the monthly average maximum and minimum temperatures of a given month compared to the previous month, for all months.

$$T_{DI} = \frac{T}{21} - 1 \qquad (1)$$

$$T_{UI} = \sqrt{\frac{\sum_{i=1}^{12}\left[\left(T_{ave_i}^{max} - 21\right)^2 + \left(T_{ave_i}^{min} - 21\right)^2\right]}{24}} \qquad (2)$$

$$RI = \frac{\sum_{i=1}^{12}\left(T_{ave_i}^{max} - T_{ave_i}^{min}\right)}{12} \qquad (3)$$

$$SI = \frac{\sum_{i=1}^{12} abs\left(T_{ave_i}^{max} - T_{ave_{i-1}}^{max}\right) + \sum_{i=1}^{12} abs\left(T_{ave_i}^{min} - T_{ave_{i-1}}^{min}\right)}{24} \qquad (4)$$

where T is the observed temperature, T_{DI} is the instantaneous ambient temperature departure index, T_{UI} is the ambient temperature uniformity index, $T_{ave_i}^{max}$ and $T_{ave_i}^{min}$ are the long-term average monthly maximum and minimum temperatures for month i, respectively, *RI* is the range index, and *SI* is the steadiness index.

Results

According to equation (1), the ambient temperature departure index for a functional temperature homeostasis regime of humans ranges from -1.0 to +1.0, with a value of 0 indicating an ambient temperature condition (Figure 1). The ambient temperature departure indices of -1.0 and +1.0 indicate, respectively, the approximate threshold conditions for hypothermia and hyperthermia under a prolonged exposure time.

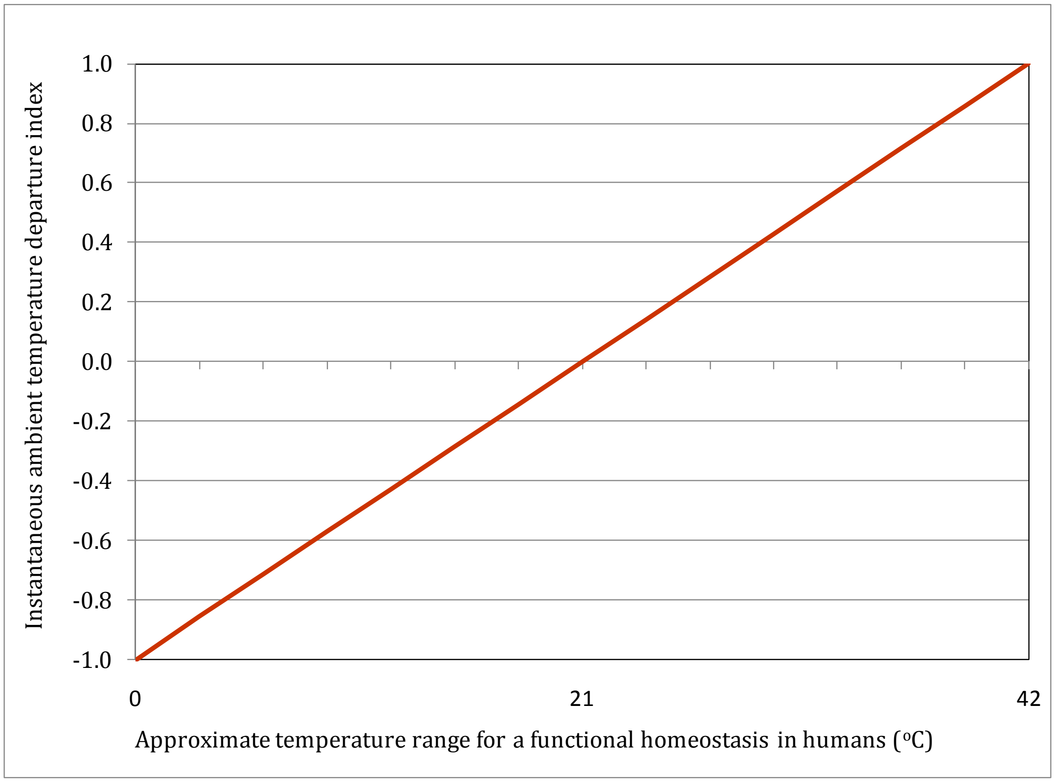

Figure 1. Instantaneous ambient temperature departure indices for a functional temperature homeostasis regime in humans

According to equation (2), the average ambient temperature uniformity index for a functional homeostasis regime ranges from 0 to 21. A zero index value indicates a steady ambient temperature state. Steady states of both hypothermia and hyperthermia have index values of 21.

In this work, the average ambient temperature uniformity index values for the selected sample cities were computed and ranked from the lowest to the highest in their continental subgroups of Africa, Asia, Europe, North America, Oceania, and South America. According to this index, Addis Ababa, Ethiopia, has the most optimal environmental condition from the selected locations in which the human body system would have evolved, as shown in Table 1. Figure 2 shows the ranked average ambient temperature uniformity index magnitudes for the selected cities around the world.

The results of the range index and steadiness index focus on selected cities from each continent, which have the lowest ambient temperature uniformity indices. A summary of the results of all these indices is presented in Table 2. The steadiness index results for the selected cities are also illustrated in Figure 3. While Addis Ababa has also the lowest range index, Manila, The Philippines, has the lowest steadiness index. Interestingly, Addis Ababa's steadiness index is practically the same as the ambient temperature steadiness index, which can be determined as (36.8 – 21)/21 = 0.75. An environment that has continuous ambient temperature of 21 in which a human with a constant body temperature of 36.8 lives would have a steadiness index of approximately 0.75. In general, low steadiness index values suggest high year round persistence of proximate environmental condition to the ambient temperature state. Other localities in different continents with low ambient temperature uniformity index are Jerusalem, Athens, Honolulu, and Rio de Janeiro.

This finding that Addis Ababa's vicinity may have been favorable for early human's functional homeostasis is consistent with earlier findings using other approaches such as DNA analysis, early plant domestications (Diamond, 2005), and an ongoing linguistic investigation by this author.

Table 1. Average ambient temperature uniformity index values for selected cities around the world

Africa		Asia		Europe		North America		South America and Oceania	
Addis Ababa	0.29	Jerusalem	0.44	Athens	0.41	Honolulu	0.30	Rio de Janeiro	0.30
Nairobi	0.32	New Delhi	0.45	Rome	0.44	Los Angeles	0.30	Buenos Aires	0.34
Lagos	0.34	Tokyo	0.45	Paris	0.50	Washington, D.C.	0.57	Mexico City	0.41
Accra	0.35	Islamabad	0.49	London	0.55	Vancouver	0.60	Bogota	0.48
Bamako	0.46	Tehran	0.55	Madrid	0.57	Toronto	0.74	Manila	0.35
Khartoum	0.50	Beijing	0.71	Berlin	0.66	Denver	0.77	Darwin	0.39
Cape Town	0.52	Moscow	0.88	Prague	0.71	Winnipeg	1.11	Canberra	0.55

Table 2. Average temperature range and steadiness indices for selected cities around the world

City	Addis Ababa	Jerusalem	Athens	Honolulu	Rio de Janeiro	Manila
Ambient temperature uniformity index	0.29	0.44	0.41	0.30	0.30	0.35
Range index	7.1	10.8	9.6	8.2	9.1	8.0
Steadiness index	0.75	2.50	3.00	0.83	1.00	0.67

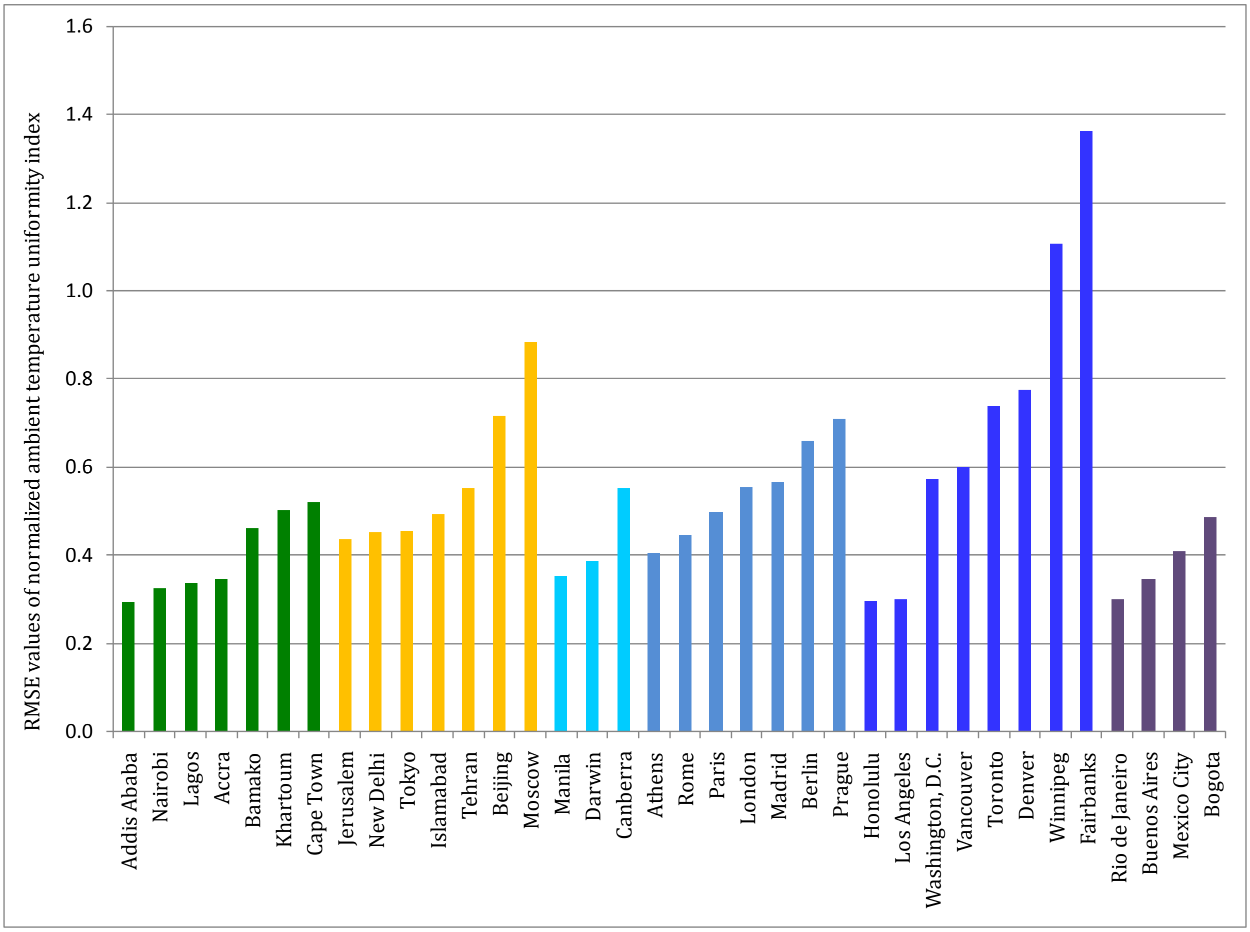

Figure 2. Average ambient temperature uniformity index values for selected cities around the world

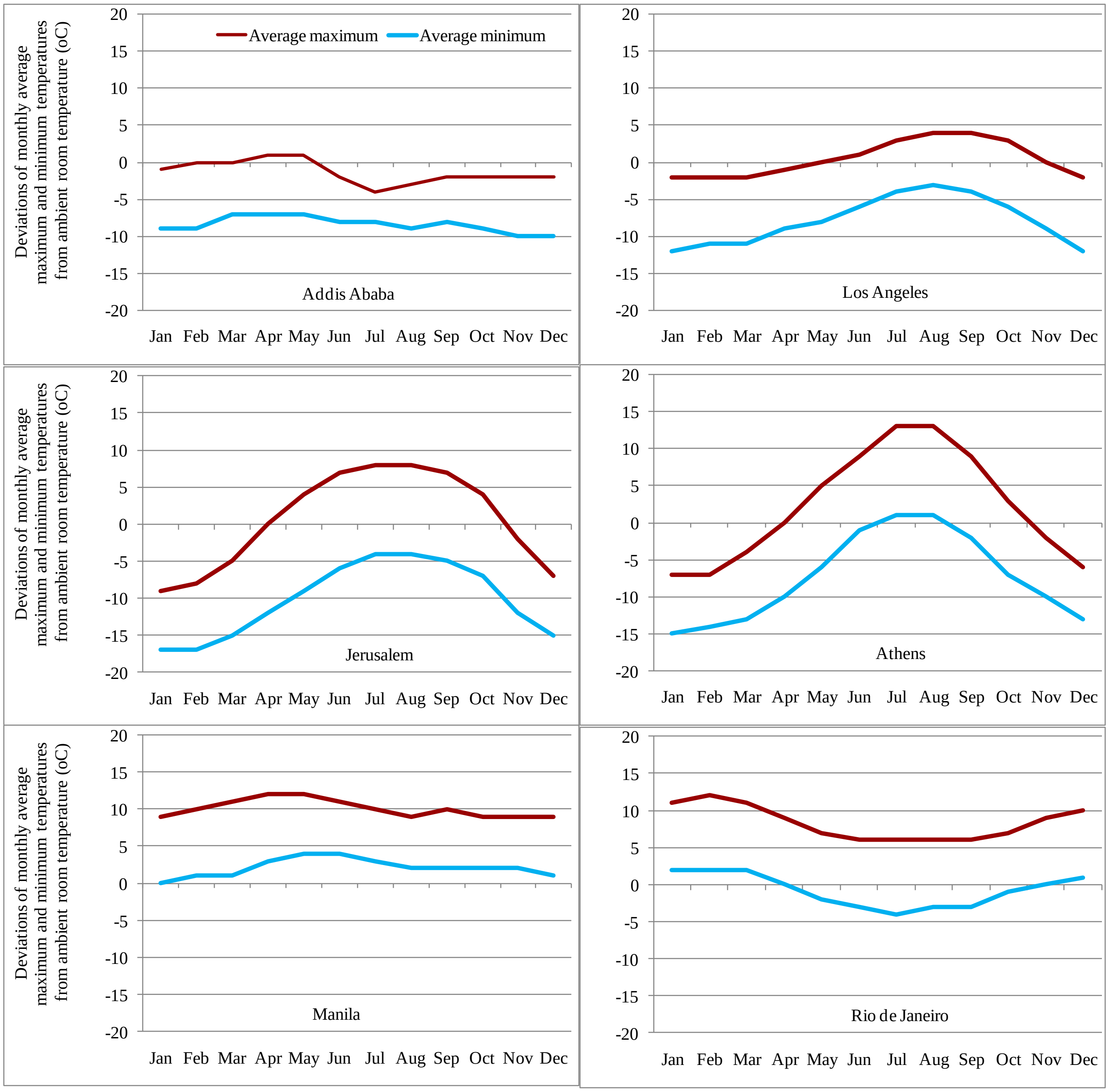

Figure 3. Illustration of ambient temperature steadiness for selected cities around the world

Discussion

As the quest about the impact of projected climate change on the habitat ranges of plants and animals shows bearings on planners and decision makers for the future, the curiosity to better understand the underlying causative factors of the historical comfort zones of these plants and animals comes into the picture of the past-future continuum of life on earth. Emerging studies report about the reactive responses of plants and animals to climate change through movements from their natural ranges (Loarie, et al., 2009). These studies point to far reaching implications because of these movements since some ecosystems, such as mountains, have 'nowhere to go'. On the other side of this past-future continuum of life lies the quest to better understand how environmental characteristics may have affected or controlled the evolution of humans and behavioral developments (National Academy of Sciences, 2010) and by extension the natural habitats of plants and animals. The intersections of these quests provides us both challenges and opportunities to make informed planning for the future while making efforts to better understand the environmental conditions of the past. The projection of environmental conditions would be more meaningful when we have sufficiently characterized and established historical environmental factors that were the undercurrents of its existence. The work reported herein has attempted to take a step in this direction by looking at historical ambient temperature data as a possible causative factor for the environment of human origin. While this attempt is limited to the use of homeostasis in humans to make a deduction about the environment of our origin, to the extent that we are part and parcel of ecosystems, it is likely to provide us a lead in the characterization of the history of ecosystems.

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In the Root of the Indo-European Language Tree

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Abstract

This work presents various collections of likely cognates from the Oromo language and the Indo-European language family and opens a new frontier of research in the study of the root of the Indo-European language tree and the origins of human languages. It presumes that those words that have been in use more frequently to express various concepts and physical matters may have been, of necessity, likely among the earliest words to have been formed, more commonly used since their formations, and hence less forgotten along the way of humanity's long journey. It points to a new and unique opportunity for a focused study on the origin of human languages.

Introduction

Our collective quest for a better understanding of the origin and evolution of human languages has attracted considerable efforts in the past and continues on today (Dominguez and Rakic, 2009). In Friedrich Nietzsche's work, the significance of language for the evolution of culture is suggested to lie in the understanding of language as a separate world beside the other world (Nietzsche, 1996). The innate desires and needs by early humans to express their observations of the environment in which they lived and thrived as intelligent beings may have been the drivers for the genesis of the use of words, phrases, and sentences. This thesis presumes that the availability of the environment in which early humans lived preceded the desires and needs to use words, phrases, and sentences to express their observations in that environment. The continuity of this use in the form of oral and written communications as well as cultures may be considered our inheritance of their innate desires and needs for the same purposes of living and thriving in the environment in which we find ourselves. Parallel to biological information provided by genes, human languages provide vital clues to human history (Pagel, 2000; Gray and Jordan, 2000). They are also conceived as cultural replicators with behavior and fidelity that can rival that of genes (Pagel, 2009). Some of the extensively researched and established language families are the Indo-European languages (Gray and Atkinson, 2003). The base of these languages is a presumed dead language known as the proto Indo-European.

Through the study of phonological changes, among others, linguists reconstructed the Indo-European language family tree from a presumed dead protolanguage Indo-European, which is believed to have been spoken some 10,000 years ago (Fitch, 2007). These reconstructions have inspired Charles Darwin's biological evolution (Fitch, 2007). It can be also argued that the evolution and history of human languages provide important clues to that part of early history of humanity and the world, which have not been understood well enough yet but are being approached through various scientific disciplines, including DNA analysis, archeology, anthropology, and paleontology. In addition to enriching our knowledge of the history of early humans, getting to the root of the Indo-European language tree, unraveling what languages and linguistic structures lie behind it, and making a scientific push along this research frontier may possibly lead to uncovering some clues towards the studies of the origin of human languages. In effect, this work takes a step towards getting new insights about the root of the Indo-European language tree and points to a new frontier in the study of the origin of human languages, a subject of an ongoing investigation by this author.

By presenting various collections of cognates, words with similar forms and related meanings, to their counterparts in some of the Indo-European languages including English, the findings in the current work bring in a new insight to bear on the presumption that proto Indo-European is a dead language. These collections of words are obtained from the Oromo language, which is used today by millions in East Africa, mainly in Ethiopia, and the Amharic language, Ethiopia's official language. In addition to bringing this new insight to the root of the Indo-European language tree, this pool of words has led to a focused ongoing research by this author on the origins of human languages.

Methodology

Some of the various means linguists and evolutionary theorists have used to bridge the gap between lexicons in different environmental settings are the studies of cognates and glossogeny. Lieberman, et al. (2007) used the frequency of word use to quantify the pattern of language change. Different criteria were used in the current work to determine whether a word in the Oromo language is a cognate of an English word or its cognates thereof in the Indo-European language family. The first criterion is that the Oromo word should have the same or a closely similar meaning to its English counterpart. The second criterion is that the two words, or its cognate thereof, should have in common at least 50% of the consonants used in the cognates. Third, these cognates should have similar vowels that are used to pronounce the consonants. Fourth, the Oromo word is a closer cognate to an older version of Indo-European language than its counterpart in the English language. Fifth, due to the evolutionary history of words, certain consonants may be replaceable with others, such as *d* with *t*, *b* with *v*, *f* with *p*, or vice versa.

For an instance of consonant sound exchangeability, take the word *lubu*, an Oromo word that means soul. Its close cognates in the Latin, Gothic, Old English, Middle English, and English are *lubēre*, *lubō*, *lufu*, *lufu*, and *love*, respectively. While most of these cognates use *lu-* sound in them, according to these words, the older languages have seemingly closer cognates to the Oromo language word *lubu* than the English word *love*. Such an evolutionary departure shows divergences both in meaning and word spelling.

I start the comparison of various words commonly used in the Oromo language from the word *eye*, which is then used as the bridge and window from the Oromo and Amharic languages to the Indo-European and other international languages (see Table 1).

Table 1. Possible cognates of the word *eye* as a potential bridge between various international languages

No.	Term	Language	No.	Term	Language
1	Acs	Latvian	17	Occhio	Italian
2	Auga	Icelandic	18	Ochi	Romanian
3	Auge	German	19	Oci	Slovenian
4	Ayin	Amharic	20	Oeil	French
5	Begi	Basque	21	Oga	Swedish
6	Ege (Eage)	Old English	22	Ojo	Spanish
7	Eie (Ie)	Medieval English	23	Olho	Portuguese
8	Eye	Danish	24	Oko	Serbian
9	Eye	English	25	Oko	Slovak
10	Ghajn	Maltese	26	Oko	Polish
11	Glaz	Russian	27	Ollo	Galician
12	Goz	Turkish	28	Oog	Dutch
13	Ija	Afan Oromo	29	‘Oog	Afrikaans
14	I’y	Hebrew	30	Oye	Norwegian
15	Je	Haitian	31	Oyen	Ukrainian
16	Jicho	Swahili	32	Yan	Chinese
			33	‘Yn	Arabic

I then present comparisons of over sixty other words collected from the Oromo language with their likely cognate counterparts in the various Indo-European languages. These cognate words that are compared are categorized into various groups of use including for and related to 1) human anatomy, 2) human emotion including faith and conflict, 3) living necessity, 4) living environment, and 5) time concept. These categories are selected with the presumption that those words that have been in use more frequently to express these categories of uses may have been likely, of necessity, 1) among the earliest words to have been formed, 2) more commonly used since their formations, and hence 3) less forgotten along the way of humanity's long journey.

The basic reason to start the comparison with the word *eye* is its exemplary nature to the above three factors used for selecting the words I compared. As a sensory organ, the physical human organ eye provides a virtual bridge between the physical world and the complex thought processes that take place in the brain. In other words, this word is considered to be particularly significant for this study because the sensory organ that this word describes is considered vital in forming and maintaining the virtual bridge between the external physical world and the internalized information processing system. In its functional state, there is a one way steady flow of information over this virtual bridge, which is then processed by the brain. The processed information is used to take spontaneous actions, stored as memory, or permanently discharged by way of forgetfulness. The functionality of this sensory organ doesn't seem to vary drastically among humans in different natural environmental settings or the physical world. In essence, under normal conditions, the mobility of this sensory organ is comparable to that of its carrier in a conscious functional state. Therefore, this study hypothesizes that this sensory organ is implicitly the most frequently used in its class for the functioning of the memory apparatus, thus lending itself to the corollary that the word that describes it is likely to be very resistant to evolutionary changes. Furthermore, this study hypothesizes that a word that stands for a matter that is observed by the eye or engages the mind more frequently has less propensity for evolutionary changes.

On the other hand, there are words that are associated with various physical and perceptive matters that are stored and passed down from one generation to the next generation. These words may not necessarily have the same level of mobility as the word *eye* or the sensory organ described using this word. For instance, the word *rock* refers to the same physical matter irrespective of the natural environmental setting in which it is found. However, the utility of this term for the purpose of describing or conveying information about this particular physical matter in different environmental settings, or languages, goes only as far as the ability and propensity of the user to adapt an equivalent term for the same matter in the lexicons used in these different environmental settings. Thus the qualitative difference between what the two words, *eye* and *rock*, describe can be characterized as pseudo permanently mobile (PPM) and willing permanently mobile (WPM), respectively. The differences in these attributes may be due to two possible reasons: 1) the differences in the spatial and temporal origins of these attributes and 2) the memory losses in the spatial and temporal mobility of the information processing system that is used to store and transmit these attributes. Irrespective of the sources of these differences, the state of human languages in our world doesn't seem to be readily flexible to adaptive utility simply because of our propensity to retain, perhaps subconsciously, what we inherited from our ancestors. It is the understanding of such salient features of human languages that will likely lead to their systematic further mapping and using that as a springboard to the study of the origins of human languages.

Collected Likely Cognates

After focusing specifically on the cognate structure of the word *eye* among the Oromo, Amharic, Indo-European, and other international languages, this study sought the various collections of cognates that are observed by the eye or engage the mind more frequently for each of the five categories of use described above. Summaries of the collected words are presented in Table 2 to Table 6 for these five different categories of word uses.

Table 2. A collection of cognates for or related to human anatomy (partial sources: Gamta, 2004 and www.dictionary.com)

Oromo	Amharic (Greek)	Latin	Old Norse (Indo Euro.)	German (Goth)	Old English	Middle English	English
ija	**ayin**			**auge**	**ēge, ēage**	**eie, ie**	**eye**
hadda					hēafod, hafod	he(v)ed	head
hari					hǣ	haire, heer	hair
luka			leggr			leggr	leg
gura		auris	eyra		ēare	ere	ear
fana	fana				fōt	fōt	foot
huddu					buttuc	buttok	buttock
mata		mēta					meta
kintiri		clītoris					clitoris
fuchi		vāgīna					vagina

Table 3. A collection of cognates for or related to human emotion including faith traditions and conflict (partial sources: Gamta, 2004 and www.dictionary.com)

Oromo	Amharic (Greek)	Latin	Old Norse (IE)	German (Goth)	Old English	Middle English	English
lubu		lubēre		(lubō)	lufu	lufu	love
du’e			deyja			dien, deien	die
kafana	kafan (kóphinos)	cophinus				cofin	coffin
dhara		errōr				errour	error
haramu	haram						harem
gadhe					gāhi	gai	gay
milki				(glūck)		luc, lucke	luck
kolf(e)an			hlǣja	(hlahjan)	hlæh(h)an	laughen	laugh
bada					bæddel	badde	bad
gad(e)an	(hádēn)	satis		saths	sæd	sæd	sad
gali					gǣlan	gol	goal
dula		duell					duel
raya		reg(ere)	(reg)				regiment
werara	warara				werre	werre	war
tarre	tarta				ārǣdan	arrayen	array
eye					gēse	yes, yis	yes
	kineliq		knouleikr		knoulāc	knoulec he	knowledg e
holi					hālig	holi	holy
gofta	gheta			got, guth			god
alaba			flap			flagge	flag
kora(saba)		congressus				congres se	congress

Table 4. A collection of cognates for or related to living necessity (partial sources: Gamta, 2004 and www.dictionary.com)

Oromo	Amharic (Greek)	Latin	Old Norse (Indo Euro.)	German (Gothic)	Old English	Middle English	English
buddena				(fōdjan)	fōda, fēdan	fode	food
kita	kita						pizza, pitta
bedde				badi	bedd	bedd	bed
farso					bēor, bjōrr	bere	beer
dabala		duplus				duplus	double
dughe(an)			drekka	drinkan	drincan	drinken	drink
kuti	kurat		kuti		cytten	cutten	cut

Table 5. A collection of cognates for or related to human environment (partial sources: Gamta, 2004 and www.dictionary.com)

Oromo	Amharic (Greek)	Latin	Old Norse	German (Goth)	Old English	Middle English	English
ishi	isua				hēo, hīo	sēo, sīo, sīe	she
nama	(ōnoma)	nōmen	nafn	name (namō)	nama	nama	name
damme							madame
laga	(lākkos)	lacus			lagu	lak(e)	lake
lencha					lēo	leon	lion
walda				wild	wilde	wilde	wild
fora					feorr	far, fer	far
Sorsa						Sīrius	Sirius
kamadi					hwǣte, kweit	whete	wheat
nughi	nug						negro
kello					geolo	yelou	yellow
hadi			hvītr	(hweits)	hwīt	whit(e)	white
farda	faras			pferd			horse
komme			koma		cuman	comen	come
boro			borg		burg	borogh	borough
ummata		commūnitās				comunete	community
soke			sœkja	suchen	sēcan	seken	seek
sacha'e					serchier	serchen	search
kilensa	(klīmat)		(klei)			climat	climate
dhaka					rocc	rokk(e)	rock
	ayer	āēr				eir	air

Table 6. A collection of cognates for or related to time concept (partial source: Gamta, 2004 and www.dictionary.com)

Oromo	Amharic (Greek)	Latin	Old Norse (Indo.Euro.)	German (Gothic)	Old English	Middle English	English
yero			ār	jahr	gēar	yeer	year
bari(te)	barra		bjartr	(bairht)	breht, beorht	breht, beorht	bright
dukana					deorc	derk	dark
bara		æra			ār		era
wache			vaka	(wakan)	wacan (wōc)	waken	wake
fuldur(a)		fūtūus				futur	future
dur		dūrāre				durer	during

Discussion

These various collections of cognates from the Oromo, Indo-European, and other international languages appear to present a new insight into the early history of languages, cultures, and humanity. This data is likely to reopen the view that Indo-European is a dead protolanguage. It is presumed that to the extent that cognates for the same physical matter or conceptual expression exist among different languages, they show the possibility of these cognates being of the same origin and divergences of word usage over time or the resistance thereof. These findings are in agreement with the results of DNA analyses of samples of people around the world, which indicate that humanity migrated out of East Africa tens of thousands of years ago (Zhong, et al., 2010; Li, et al., 2008; Jakobsson, et al., 2008; Liu, et al., 2006). Thus, the pool of cognates provided in this work are likely to present vital clues about the presence of unbroken virtual bridges in chaotic sound bites in various languages of the world, including those outside the Indo-European language family. This significance of this work can be seen on various levels. It gives clues about how much social consciousness and adaptation to the natural environment, including plant and animal domestications, had been established before early humans started to migrate out of Africa. These clues present us some leads to the unanswered question of whether indigenous crops developed in Ethiopia or those presumed to have arrived from the Fertile Crescent launched Ethiopia's early food production (Diamong, 2005). Two possible hints for this lead are the likely changes from *nughi* to *negro* and *kamadi* to *wheat* (see Table 5). The possibility of social organization consciousness prior to the migration out of Africa cannot be ruled out. If the word *flag* proves to be a cognate of *alaba* (Table 3), both of which have similar meanings, it is likely to explain the striking similarities of the tricolor flags of many nations around the world. If we consider a possible change over time and space of blue for black, we would readily observe that many nations around the world use the tricolors of black (blue), red, and white for their flags. For the Oromo, the tricolors of black, red, and white symbolize deep meanings that encompass the past, the present, and the future laced with faith traditions. Granted that these collections of cognates support our established knowledge through the study of our DNAs, they will not only narrow down the domain space for the study of the origin of human languages, but also highlight the ongoing progress of humanity's enlightenment.

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